1995
Official Copy

USE OF THE SCS-SCHEDULER PROGRAM — SOUTHERN HIGH PLAINS

Terry A. Howell[1], Karl Johnson[2], and Donald A. Dusek[3]

ABSTRACT

The SCS-Scheduler can improve irrigation water management but has not been evaluated widely in the Western U.S. The SCS-Scheduler program was evaluated on a farm in the Southern High Plains since 1991. The program provided useful information to the grower to schedule irrigations for winter wheat, corn, and sorghum. Field yields from scheduled fields were considerably above county-wide average irrigated yields and water use efficiency values indicated good irrigation management. Crop coefficients were determined for use in the SCS-Scheduler for wheat, corn, sorghum based on measured evapotranspiration at Bushland. The SCS-Scheduler PET (potential evapotranspiration) method was found comparable with the NP-PET values based on the Penman-Monteith equation but slightly higher than those estimated using Ref-ET based on ASCE Manual No. 70.
Keyword: Corn, Evapotranspiration, Irrigation scheduling, Management, Sorghum, Wheat

INTRODUCTION

The SCS-Scheduler program (Shayya and Bralts, 1994 and Shayya et al., 1990) for irrigation scheduling was evaluated for the Southern High Plains for corn, sorghum, and wheat. Crop coefficients for these crops were determined based on lysimeter measured evapotranspiration values, and the potential evapotranspiration (PET) method used in the SCS-Scheduler was compared to other programs to facilitate other crop coefficient transfers.

METHODS

Research and evaluation of the SCS-Scheduler program was started in 1991 on the Johnson Farm south of Morse, TX in Hutchinson County. The soil type on the farm is classified as Sherman

[1] Research Leader (Agric. Engr.), USDA-ARS, Conservation & Production Research Laboratory, P.O. Box 10, Bushland, TX 79012

[2] CEO, Johnson Farms, P.O. Box 95, Morse, TX 79062

[3] Agronomist, USDA-ARS, Conservation & Production Research Laboratory, P.O. Drawer 10, Bushland, TX 79012

silty clay loam. A Campbell Scientific 012 weather station was installed on the farm to provide the necessary weather data for the program. The station was situated over native grass in an isolated corner of the equipment yard about 500 to 1,000 ft from any obstructions. Irrigations were scheduled using the SCS-Scheduler for graded furrow
irrigations (some fields used surge methods) applied to winter wheat, corn, and sorghum, and soil water was routinely monitored with gypsum soil blocks installed at 1, 2, 3, and sometimes 4 ft depths using a Delmhorst KS-1 meter. Other comparisons were made with irrigation experiments conducted at Bushland, TX in Potter County using weighing lysimeters and sprinkler irrigation on winter wheat, corn, and sorghum. Weather data for Bushland were obtained from the ET weather station located over irrigated grass using a different but similar set of instruments. The soil type at Bushland is classified as Pullman clay loam and is similar to the Sherman silty clay loam soil at the Johnson Farm.

In the 1991 season, initial runs were made using weather data obtained from the nearby weather station (about 15 mi. away) operated by the Texas Agricultural Experiment Station at Etter, TX in Moore County. Initial operation encouraged further program use. In 1992 a weather station was installed on the Johnson Farm, and its data were used from March 3 for the remainder of the 1991-92 wheat season to the present. The SCS-Scheduler was used for wheat and corn in 1991 and 1992 and sorghum in 1993. Generally, irrigations were timed to maintain 75% of the available field capacity with wheat irrigations generally avoided until after March and corn not irrigated until the 6-leaf stage. Corn irrigations were stopped when the starch line progressed about half way down the kernel.

RESULTS

The farm yield results are presented below and generally indicated that crop yields of the fields managed with the SCS-Scheduler exceeded comparable mean county irrigated yields (Amosson et al, 1995). Since winter wheat and sorghum are widely produced under limited irrigation in this region, county average yields may be lower than yields expected for full irrigation. However, corn is usually fully irrigated in this region. Yields exceeded county average yields by over 25% for corn, over 50% for sorghum, and over 30 to 40% for wheat.

CROP	FIELDS	AVG. YIELD bu/ac	COUNTY AVG. YIELD bu/ac	YIELD COMPARISON % above County Yield
Winter Wheat				
1991-92	2	88	59	49
1992-93	7	79	60	32
Corn				
1992	2	240	190	26
1993	5	199	157	27
Sorghum				
1993	1	143	92	55

A freeze on 10 March 1992 killed 18 to 42% of the wheat tillers. No adjustment was made to the SCS-Scheduler for the reduced tillers. The soil water sensors and program computed ET indicated similar water use trends despite the heavy tiller reduction. By monitoring both sources of information, the need for irrigations in late March was anticipated even though the crop appearance did not warrant irrigation yet. The value of the growing degree day (GDD) time scale available with version 3.0 improved corn irrigations in 1992. The GDD accumulation in June indicated more rapid crop development than the simpler time scale, and a mid June irrigation avoided a potential yield reduction. In 1993, wheat yields were a little better than in 1991-92 while corn yields suffered from heat stress that reduced yields. Water use efficiencies (grain yield per unit irrigation plus rainfall) averaged about 3.2 and 3.4 bu/ac-in. for wheat in 1991-92 and 1992-93, respectively, and 6.8 and 6.5 bu/ac-in. for corn in 1992 and 1993, respectively, and 8.2 bu/ac-in. for sorghum in 1993 indicating the efficient use of irrigation and rainfall with the SCS-Scheduler.

Mean crop coefficients were determined for ET data from fully irrigated crops at Bushland. These values represent only single seasons, but should be representative for other conditions. The SCS-Scheduler K_c values are mean crop coefficients and input based on growing season days (time scale) or on growing degree days (thermal time scale). GDD is computed by the SCS-Scheduler using the mean air temperature less the lower base temperature. Most K_c values are reported in different time scales (% time from emergence to full cover and days after full cover) (see Jensen et al., 1990), so some adaptations are necessary to use previously published K_c values.

	GDD Time Scale			Season Days Time Scale		
% of Time	Corn K_c	Sorghum K_c	Wheat K_c	Corn K_c	Sorghum K_c	Wheat K_c
0	0.26	0.20	0.40	0.26	0.20	0.40
10	0.26	0.30	0.60	0.27	0.35	0.50
20	0.40	0.48	0.40	0.38	0.45	0.70
30	0.90	0.72	0.45	0.80	0.60	0.45
40	1.15	1.08	0.85	1.10	0.90	0.40
50	1.20	1.05	1.20	1.15	1.15	0.90
60	1.20	1.05	1.30	1.15	1.10	1.10
70	1.25	0.95	1.30	1.20	1.05	1.20
80	1.30	0.80	1.35	0.95	0.70	1.30
90	1.10	0.60	0.80	0.60	0.60	0.80
100	0.60	0.40	0.55	0.26	0.40	0.45
Base Temp (°F)	50	50	35			
Max. Temp. (°F)	86	100	79			
Total GDDs (°F-days)	3,000	3,300	5,000			
Total Days				180	150	310

In addition, K_c values are specific to a "reference ET" or PET method. The PET method used in the SCS-Scheduler was compared to the REF-ET (v2.1) program and to the grass reference

ET equation used in the NP-PET (North Plains-PET) network. The resulting linear regressions indicate the corrections needed to compare K_c values for the SCS-Scheduler to other published K_c values using other PET methods. The Penman-Monteith (Allen, 1990) based on REF-ET (v2.10) was similar to the Kimberly Penman equation (corrected to grass) and the NP-PET Penman-Monteith equation. The SCS-Scheduler was about 10% higher than the Penman-Monteith (REF-ET) equation, while the REF-ET FAO Penman equation was about 21% lower than the Penman-Monteith (REF-ET) equation. The SCS-Scheduler PET method agreed well with the NP-PET method, except it was slightly higher during the wheat season. These regressions can be used to translate K_c values from one base PET equation to another base PET equation.

	CORN in 1994 N = 168			SORGHUM in 1993 N = 131			WHEAT in 1991-92; N=287		
METHODS	INT. in./d	SLOPE ----	r^2 ----	INT. in./d	SLOPE ----	r^2 ----	INT. in./d	SLOPE ----	r^2 ----
Kim. Pen.	0.00	1.04	0.96	-0.01	1.11	0.98	0.00	1.01	0.96
Corr. FAO Pen.	0.02	1.14	0.93	0.00	1.18	0.94	-0.01	1.28	0.95
NP-PET (PM)	0.02	0.95	0.93	0.01	0.99	0.97	0.02	0.96	0.99
SCS-Scheduler	0.04	0.93	0.90	0.04	0.95	0.92	0.03	0.86	0.94

All methods were expressed as Y(ET method; dependent variable) = Int. + Slope * X(Penman-Monteith REF-ET method; independent variable).

Penman-Monteith Equation (REF-ET for grass)
Kimberly Penman (REF-ET corrected for grass)
Corrected FAO Penman (REF-ET)
NP-PET (North Plains PET Network Penman-Monteith equation for grass)
SCS-Scheduler (modified FAO Penman equation for grass)

SUMMARY

Overall, the SCS-Scheduler program performed rather well. Obtaining representative input data (crop, soil, and climate data) remains somewhat problematic. Future updates to the SCS-Scheduler Package will address several shortcomings of the program and facilitate easier use by growers and specialists.

REFERENCES

Allen, R.G. 1990. REF-ET, reference evapotranspiration calculator version 2.1. Utah State University, Logan.

Amosson, S., J. Smith, and W. Rauh. 1995. Texas crop & livestock enterprise budgets Texas High Plains. Texas Agric. Extension Service, Amarillo, Texas.

Jensen, M.E., R.D. Burman, and R.G. Allen. 1990. Evapotranspiration and irrigation water requirements. ASCE Manual No. 70. Am. Soc. Civil Engrs., New York, NY.

Shayya, W.H. and V.F. Bralts. 1994. Guide to SCS-Microcomputer irrigation scheduling package, SCS-Scheduler Version 3.00. USDA-Soil Conservation Service and Department of Agricultural Engineering, Michigan State University, East Lansing, MI.

Shayya, W.H., V.F. Bralts, and T.R. Olmsted. 1990. A general irrigation scheduling package for microcomputers. *Computers and Electronics in Agriculture* 5:197-212.

Fact Sheet – SCS Scheduler

SCS Microcomputer Irrigation Scheduling Package
Version 3.0

May 1995

Developer

Department of Agricultural Engineering, Michigan State University, East Lansing, Michigan, and the U.S. Department of Agriculture, Natural Resource Conservation Service (formerly the Soil Conservation Service).

Description

SCS Microcomputer Irrigation Scheduling Package (ver. 3.00) (SCS-Scheduler) computes the water balance of crops and determines irrigation needs. SCS-Scheduler can handle an unlimited number of fields. Measured soil water data can be used to update soil water levels during the growing season.

SCS-Scheduler uses soil (soil water holding capacity by depth), crop (rooting development and crop coefficients), and weather (daily air temperature maximum and minimum, daily relative humidity maximum and minimum, six hour mean wind speeds, daily solar radiation, daily net radiation), and farm data (rainfall and irrigation) data. Historical information on air temperatures and rainfall is used to establish past records for determining rainfall probabilities and long-term evapotranspiration (ET) trends. Weather data are entered manually or automatically logged from an automated weather station. The water balance is computed based on the estimated ET and deep percolation and input rainfall and irrigation data. The crop coefficient data can be input based on a seasonal time scale or based on growing degree days.

Features

- SCS-Scheduler uses the modified FAO equation for reference or "potential" ET (ET_o).
- Local weather data from a Campbell 011 weather station can be transferred automatically via a telephone modem.
- Weekly rainfall probabilities can be directly entered or computed using historical data.
- Crop coefficients can be entered based on percent of growing season length based either on days or accumulated growing degree days (GDD).
- GDDs can be computed as the simple mean temperature less the specified base temperature.

- Rootzone depths are input and the soil water in each layer can be input.
- Measured soil water data can be used to update or adjust the water budget.
- Graphical outputs can display seasonal trends in soil water with irrigations and rainfall events.
- Graphs of excess water (either from rainfall or irrigations) and crop ET and ET_0 as daily rates or accumulated values and graphs of daily weather data can be displayed and printed.
- Graphs of historical ET_0, GDD (accumulated or daily), and rainfall probabilities can be displayed and printed.
- English or metric units can be used for weather data inputs.
- Conversion programs are provided to convert previous SCS-Scheduler files to the current version.
- An irrigation schedule can be determined based on a predetermined net irrigation amount to determine the earliest date to avoid overfilling the rootzone.
- Irrigation schedule report shows the latest date for an irrigation before the soil water is depleted to the management level.

Limitations

- Runoff is not predicted directly, but any water received above the soil saturation is considered excess (runoff or percolation).
- Alternative ET_0 equations indicated as options are not currently operational.
- Several data files are random access and not ASCII formats.
- Crop data files cannot be changed from seasonal days to growing degree days.
- Irrigation capacity is not considered as a constraint.
- Irrigation application losses are not directly considered.
- Growing degree day base temperature cannot be less than 35°F (1.7°C).
- SCS-Scheduler uses mean crop coefficients that do not directly account for irrigations or rainfall effects on ET (compared with the basal crop coefficients).

Support

Distribution diskettes and documentation are available through the Irrigation Engineers at the NRCS National Technical Centers (NTCs).

Future Developments

- Other ET_o equations can be included besides the modified FAO equation.
- Provide ASCII data input options for weather data from other files and from other weather station formats.
- Adjust GDD computations for minimum air temperatures below the lower base temperature and for maximum air temperatures above the upper temperature threshold.

Resource Requirements

SCS-Scheduler requires a MS-DOS (ver. 3.0 or higher) compatible system that has at least 512 kb (kilobytes) of random access memory (RAM) with a hard disk with at least 3 Mb of available space with either a 3-1/2 in. or a 5-1/4 in. diskette drive. A graphics adapter is needed for screen graphic displays but is not required for program operation. A Hayes Smartmodem (or Hayes compatible modem) with a 1200 baud speed is required for communication to an automated weather station. SCS-Scheduler supports the use of any IBM compatible dot matric or HP Laserjet printer. A Microsoft mouse is desirable but not required.

WORKSHOP ON

COMPUTER APPLICATIONS IN

WATER MANAGEMENT

Proceedings of the 1995 Workshop
May 23-25, 1995
Colorado State University
Fort Collins, CO

Compiled and edited by:

L. Ahuja, J. Leppert, K. Rojas
USDA-ARS, Fort Collins, CO

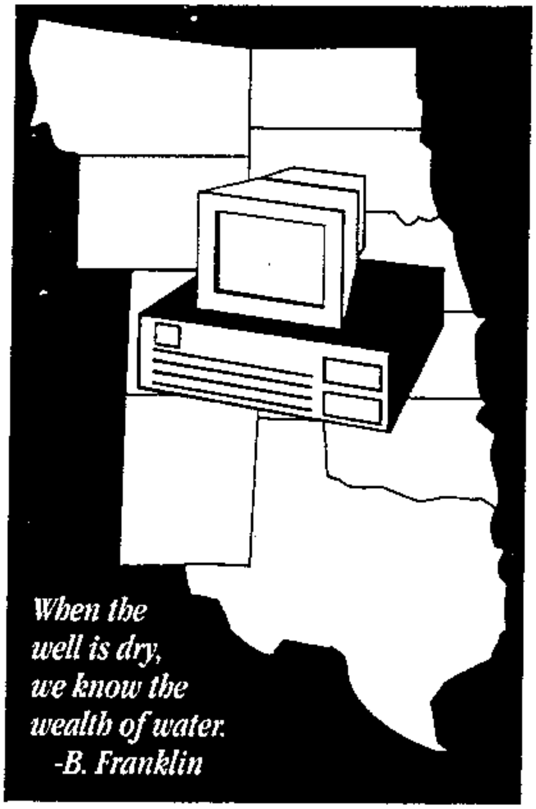
E. Seely
USDA-NRCS, Fort Collins, CO

Published by:

Great Plains Agricultural Council
Colorado State University
Fort Collins, CO 80523
GPAC Publication No. 154

Water Resources Research Institute
Colorado State University
Fort Collins, CO 80523
Information Series No. 79

EDINGS



WORKSHOP ON COMPUTER APPLICATIONS IN WATER MANAGEMENT

May 23-25, 1995
Fort Collins, Colorado

Sponsored by:
Great Plains Agricultural Council
USDA, NCRS and ARS
Colorado State University,
Department of Soil and Crop Sciences
and Water Resources Research Institute
University of Wyoming,
Cooperative Extension Service
and Water Resources Center
University of Nebraska,
Water Resources Center

COLORADO WATER RESOURCES RESEARCH INSTITUTE

GPAC Publication No. 154

Information Series No. 79